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# Comparing Zooplankton Diversity Across a Gradient of Lake Size and Dissolved Organic Carbon in the Western Lakes Region of Maine

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## Abstract

Recovery from anthropogenic acidification of lakes across the Northeast is associated with an increase in the brown coloring of lakes ("lake browning"), impacting both light attenuation into the water column and all the species that live within the lake. This study aimed to assess the impacts of lake browning on zooplankton biodiversity and abundance in the Western Lakes Region of Maine. We compared zooplankton abundance and diversity from six lakes across a gradient of lake size (10.1 ha to 125.9 ha) and total organic carbon (TOC) (3.7mg/L to 30 mg/L). Results for our small sample size suggest that lake size and TOC are not the primary drivers of zooplankton diversity. Although we did not find a relationship to lake TOC in this data set, this project provides baseline zooplankton data for the Western Lakes Region of Maine as lakes continue to change over the coming years.

## Background

In recent decades, lakes in the northeastern United States have slowly been recovering from anthropogenic acidification, resulting in increasing brown color in a process called 'browning' (Leach et al. 2019). Unfortunately, this browning has many impacts on the lake's water quality by reducing the amount of light attenuating into the water column. This, in turn, impacts all the living species in the lake from primary consumers all the way up to top predators. One important group of organisms is zooplankton. In an aquatic food web, zooplankton are one of the key components as primary consumers. Studies have shown that both the diversity and overall abundance of zooplankton decreases as a lake is acidified, including an increase in the proportion of tolerant species (Marmorek & Korman 1993). In the Western Lakes Region of Maine, Lakes Environmental Association (LEA) has seen an increase in the color in some of the lakes that they monitor every year. Further investigation into the browning of lakes and zooplankton composition and abundance is highly desired in that area. Additionally, by investigating the impacts on zooplankton biodiversity now, future studies in the Lakes Region will have past data to compare to, allowing LEA scientists to observe changes in the lakes over time.

## Objectives

The objectives for this study were two-fold; to investigate the influence of lake browning on local zooplankton communities and to collect baseline zooplankton data for the Lakes Region.

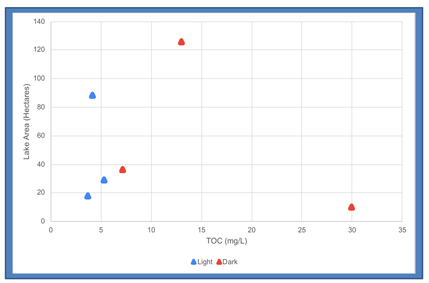


*Figure 1. Lake area and TOC (mg/L) for the six Western Maine lakes selected for this study*

*Picture 1. Cyclopoida zooplankton from Trickey Pond, identified using An Image-Based Key To The Zooplankton of North America*

## Methods

- Six lakes were sampled at night over the course of two weeks in August; two small lakes, two medium lakes, and two large lakes. One of each lake pair was selected to represent 'clear' lakes, while the others show signs of browning.
- Zooplankton samples were collected at the deep hole using a 53 µm net. Additionally, water samples were collected to assess water color, calcium, and total organic carbon (TOC).
- Samples were preserved and analyzed using three 1mL subsamples per sample jar, to determine the mean diversity and concentration of zooplankton in each lake. Zooplankton were identified using *An Image-Based Key To The Zooplankton of North America* to determine the number individuals in each of the following categories: adult *Copepoda* (both *Cyclopoida* and *Calanoida*), immature *Copepoda*, *Cladocera*, *Rotifera*, and *Diptera*.
- Additional daytime zooplankton samples were collected from under the ice over a two-week period in February from the two large lakes and the two small lakes.

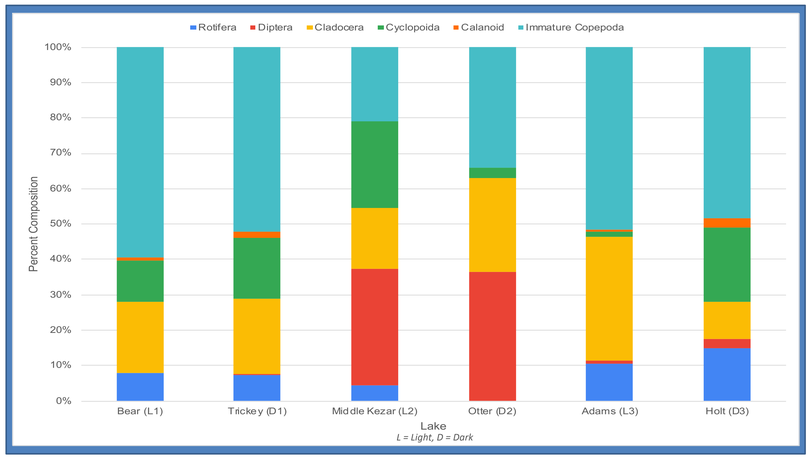


*Figure 2. Composition of zooplankton population in six Western Maine lakes*

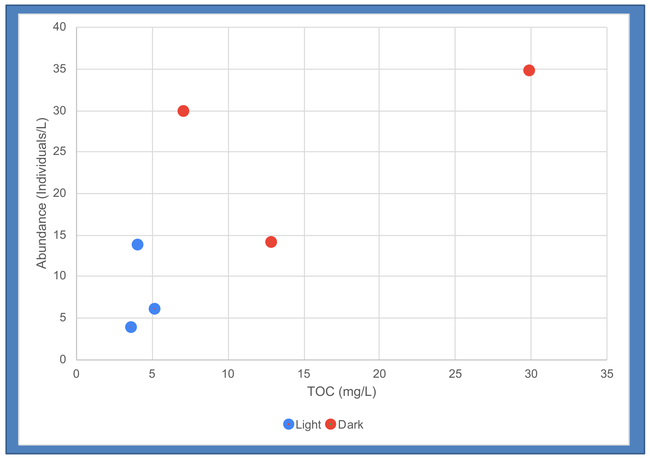


*Figure 3. Total organic carbon (TOC) in mg/L compared to abundance of zooplankton for light and dark lakes*

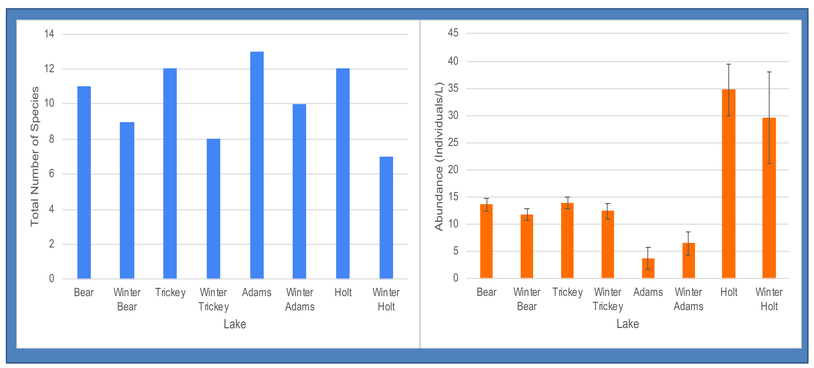


*Figure 4. Total number of species and abundance of species per liter of zooplankton in summer and winter samples*

*Picture 2. Pulling up a zooplankton net on Holt Pond, 8/30/2019*
*Picture 3. Zooplankton sample collected on Bear Pond, 2/14/2020*

| Lake Name | Bear | Trickey | Middle Kezar | Otter | Adams | Holt |
|---|---|---|---|---|---|---|
| Lake Area (hectares) | 88.2 | 125.9 | 29.1 | 36.4 | 18.2 | 10.1 |
| Maximum Lake Depth (meters) | 21.9 | 16.8 | 15.5 | 6.4 | 15.5 | 3.0 |
| TOC (mg/L) | 4.2 | 13 | 5.3 | 7.2 | 3.7 | 30 |
| Calcium (mg/L) | 2.5 | 3.1 | 2.1 | 2.6 | 2.3 | 3.7 |

*Figure 5. Environmental data for Bear, Trickey, Middle Kezar, Otter, Adams, and Holt ponds*

## Results

Results showed no significant difference in zooplankton composition or diversity between light and dark lakes (Figure 2). Zooplankton community composition likely depends on many interacting factors including lake area, depth, and TOC making each lake unique in that aspect. However, a significant difference was noted between the zooplankton abundance (individuals per liter) in light compared to dark lakes ($p<0.05$), with dark lakes containing a higher abundance (Figure 3).

When comparing summer nighttime sampling data with winter daytime under-ice data, results showed no significant difference between the abundance or composition of summer vs winter populations. However, there was a significant difference between the total number of species in each lake ($p<0.01$) with winter samples containing a lower number of species overall (Figure 4). Additionally, no Calanoid copepods were noted in the winter samples, while they were noted in all summer samples.

## Discussion and Conclusions

The finding of no significant difference in either zooplankton diversity or composition between light and dark lakes disagreed with previous studies that found that the diversity decreased with increased browning. Additionally, although a significant difference in the abundance of zooplankton between light and dark lakes was found, it was found to be the opposite trend than that noted in previous studies with the higher abundance being found in the darker lakes. We hypothesized that these disparities are likely due to the interaction of multiple factors, with lake size and depth playing a large role. Overall, this study collected excellent baseline data on zooplankton populations in Western Maine lakes to use as a comparison tool as lake variables continue to change over the coming years.

Acknowledgements
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